

Observations of Near-Bottom Currents with Low-Cost SeaHorse Tilt Current Meters

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LONG-TERM GOALS

The SeaHorse TCM is a low-cost, easy to use, robust current meter based on the drag principle. Use of a large number of low-cost instruments would result in a new high spatial resolution view of the processes and to improve the ocean state prediction. The ultimate goal is to improve this technology by including expendable option with automatic data relay after deployment and to develop a global scale program of near-bottom current observations.

OBJECTIVES

The objectives are to improve the design of the instrument, evaluate its performance in comparison with other standard current meters, accumulate experience in its deployment/recovery/operation and to promote the use of such an instrument in various applications.

APPROACH

We proposed to evaluate this instrument (which utilizes the hydrodynamic drag principle; Hoerner, 1965) in a number of settings in comparison with standard oceanographic equipment, to demonstrate the instrument's capabilities and to analyze its performance. Specifically, several organizations and researches were identified that are willing to try these instruments or assist in their evaluations.

PI is responsible for assembling and modifying the instruments and required moorings, will participate in deployment/recovery and will analyze the observational data. PI also collects and analyzes the instrument performance information (pertaining, for example, to bio fouling, potential data telecommunication, internal motion-driven power generation) required for future development.

WORK COMPLETED

During FY10 the following work was completed by the PI.

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A major experiment was conducted in the Waquoit Bay in November-December, 2009. 35 SeaHorse current meters were deployed in the Waquoit Bay and adjacent ponds (Figure 1) in order to study the shape of the tidal signal (Figure 2). The instruments were placed in major inlets/channels and in series of lines across the interior of the bay. The instruments had different ballasting and sensitivity which allowed us to optimize their performance for channel vs bay interior conditions. The deployment/recovery operations were assisted Chris Weidman and other staff at the Waquoit Bay Natural Estuary Research Reserve (WBNERR).

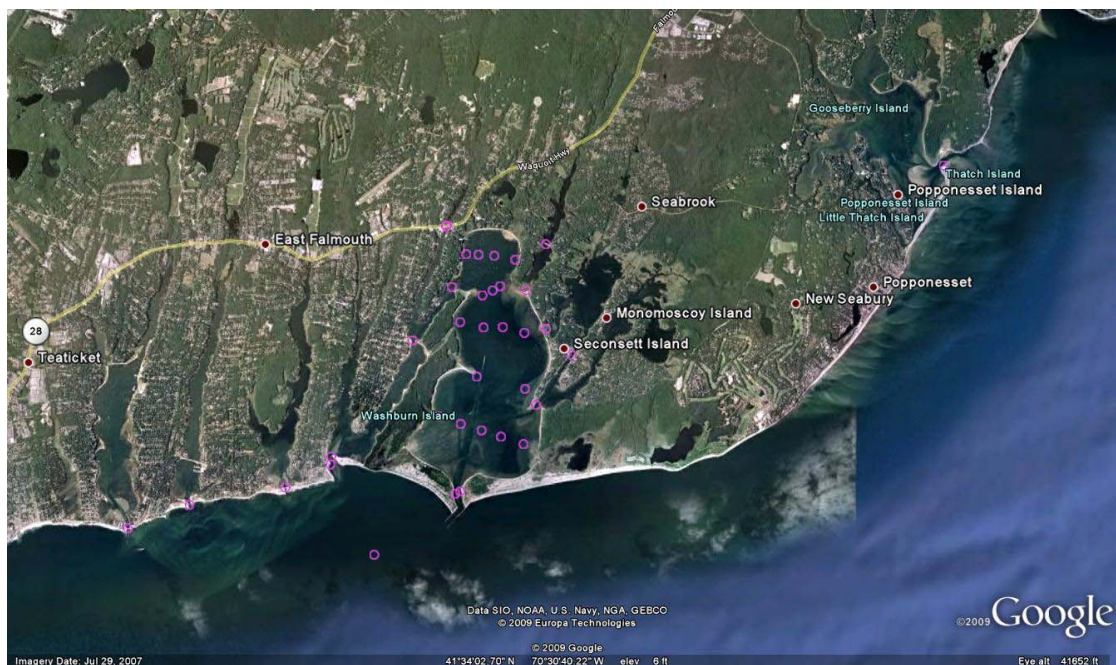


Figure 1. Deployment sites (magenta circles) of an array of 35 SeaHorse current meters in the Waquoit Bay during November-December, 2009.

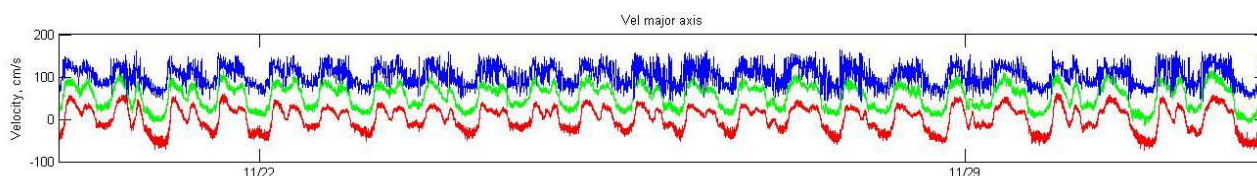


Figure 2. Example of velocity records: Waquoit Bay Inlet (red), Little River Boat Yard (green), Childs River (blue).

The tidal signal in the Waquoit Bay exhibits very dramatic double peaked highs causing so-called double high tides. This behavior was found to originate in the Nantucket Sound as two tidal waves interfere there (Figure 3). Analysis of numerical tidal model showed general agreement with the observations.

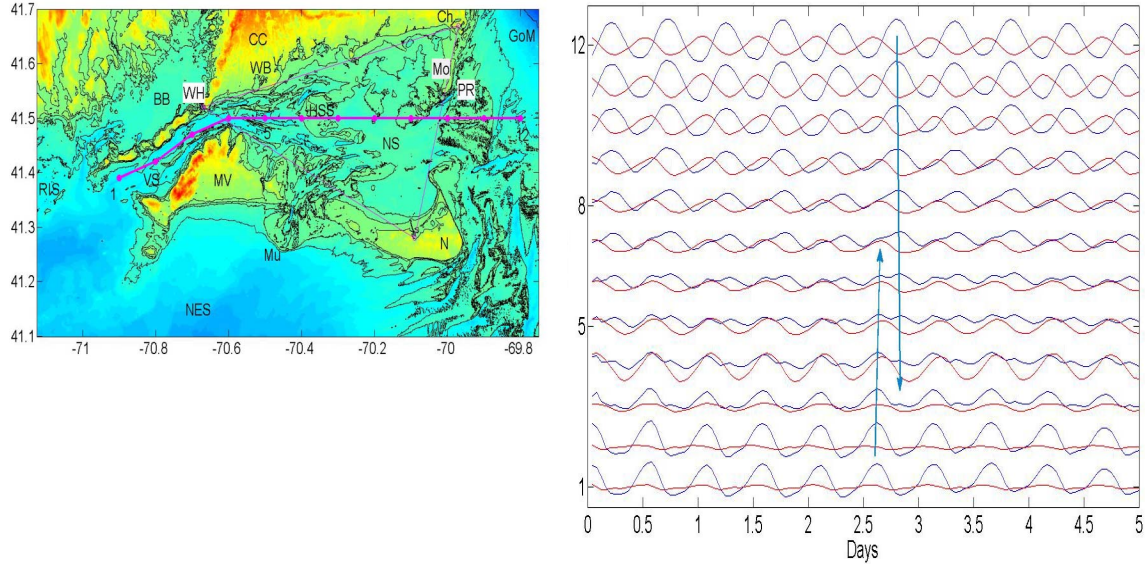


Figure 3. Propagation of tidal waves across Vineyard Sound (section nodes 1-3), Nantucket Sound (nodes 4-9), and Gulf of Maine (nodes 10-12) according to FVCOM numerical simulation. The blue curves are the surface elevation and red curves are the velocity component along the major tidal axis. Each curve is shifted upward for a subsequent node in the section. The arrows trace propagation of the surface elevation crests of two waves originating in Vineyard Sound (1) and in Gulf of Maine (12).

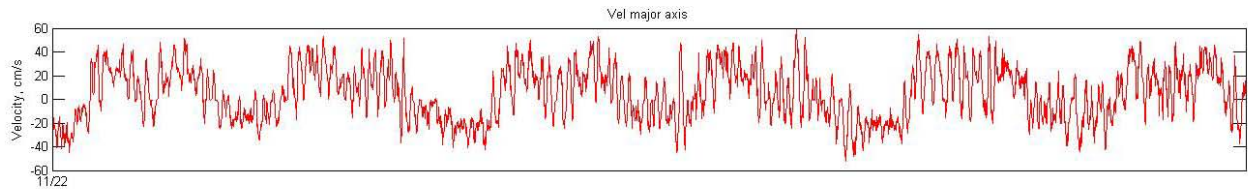


Figure 4. Expanded view of the velocity record in Childs River showing higher frequency (period about 20 min) seiches on top of M2 tidal signal.

An interesting phenomenon that was detected during the field experiment was high amplitude seiches in one of the tributaries: Childs River (Figure 4). The seiches have a period of about 20min and do reverse the flow many times during the tidal period.

The experiment turned to be largely successful, except for issues related to orientation changes seen for some instruments.

Several attempts were undertaken in order to compare long period deployments of the SeaHorse current meter alongside standard acoustic current meters. Steve Lenz (WHOI) deployed one instrument near Martha's Vineyard Coastal Observatory for 1 year. Unfortunately, the instrument was buried by moving sand and it was lost during the recovery: the rope connecting it to the moored tripod broke. Another deployment by Richard Limeburner (WHOI) in the middle of Nantucket Sound was successful. The instrument was deployed directly on the tripod carrying an ADCP in December of

2008. The tripod was lost and then found again and finally recovered in July of 2010. Thus the instrument stayed underwater for 1.5 years instead of the planned 6 months. The biofouling was significant (Figure 5). The SeaHorse current meter developed signs of performance deterioration only in late May of 2009 showing good agreement prior to that (Figure 6).



Figure 5. Recovered ADCP mooring tripod that stayed in the middle of the Nantucket Sound from December 2008 through July 2010. The SeaHorse current meter is seen attached to an aluminum arm extending to the left. Significant biofouling by barnacles is visible on all instruments.

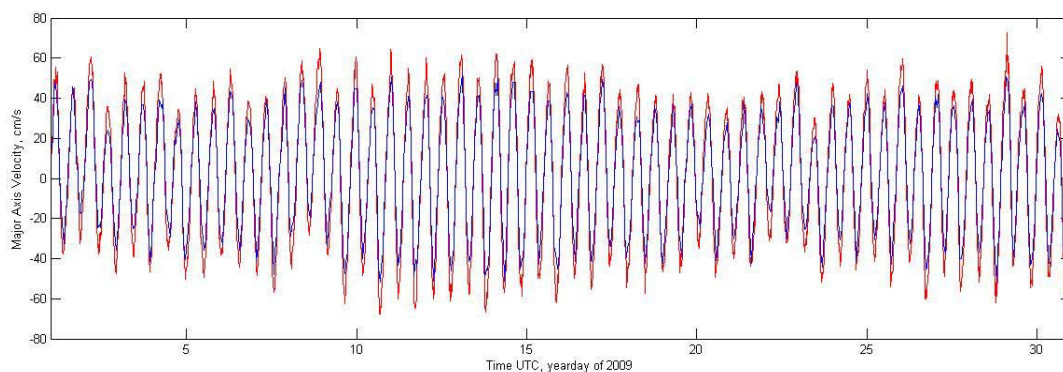


Figure 6. Comparison of the ADCP velocity record (in the bin closest to bottom, red) and the SeaHorse current meter (blue). Shown are the velocity components along the major tidal axis during the January of 2009. The SeaHorse was located closer to the bottom and experienced shadow effect from the tripod, hence measuring slightly smaller velocities.



Figure 7. Examples of multilevel deployments of the SeaHorse current meters. Left panel in Childs River: monitoring near bottom and near surface currents as well as the water level by freely swinging arm. Right panel: in Salt Pond, Eastham, MA: monitoring near bottom currents and stress.

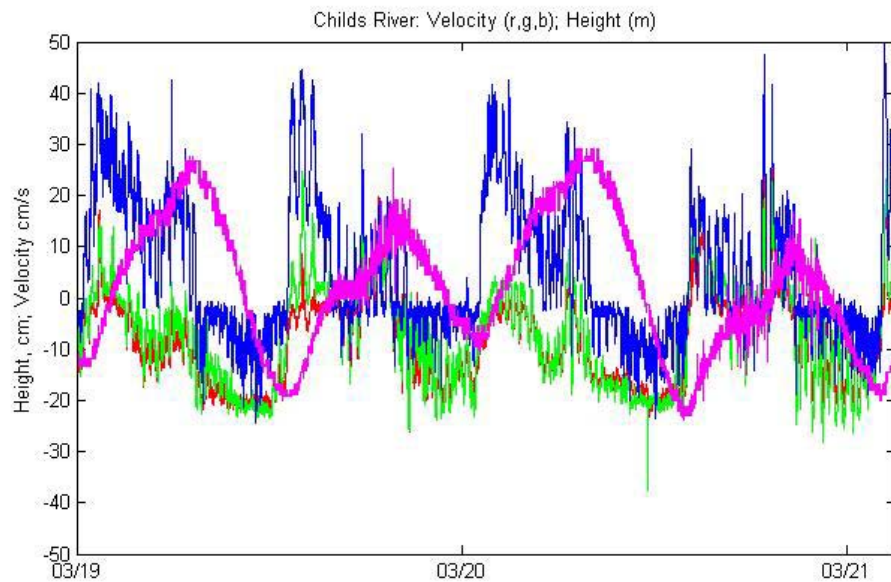


Figure 8. Example of the records in Childs River in March, 2010: near bottom velocity (blue), near surface velocities (red and green), and free surface elevation (magenta).

The SeaHorse current meters were combined in various arrangements in order to try to address various observational problems. Figure 7 (left panel) shows study of the seiches and baroclinic circulation in Childs River. The current measurements at several depth levels were accompanied by measurements of tides. Note that the point of near surface attachment was freely moving with the water surface (Figure 8). During a test in the Salt Pond, three SeaHorse current meters were deploying near the bottom thus permitting to estimate the stress.

In summer of 2010 the 4 SeaHorse current meters were deployed in the Cohasset Harbor, MA. At the same time PI supervised a project involving launching GPS drifters by high school students at the Cohasset Center for Student Coastal Research. This project was covered in the Patriot Ledger, a Boston area newspaper: <http://www.patriotledger.com/archive/x482009742/Cohasset-student-scientists-hit-the-water-to-learn-about-marine-research>

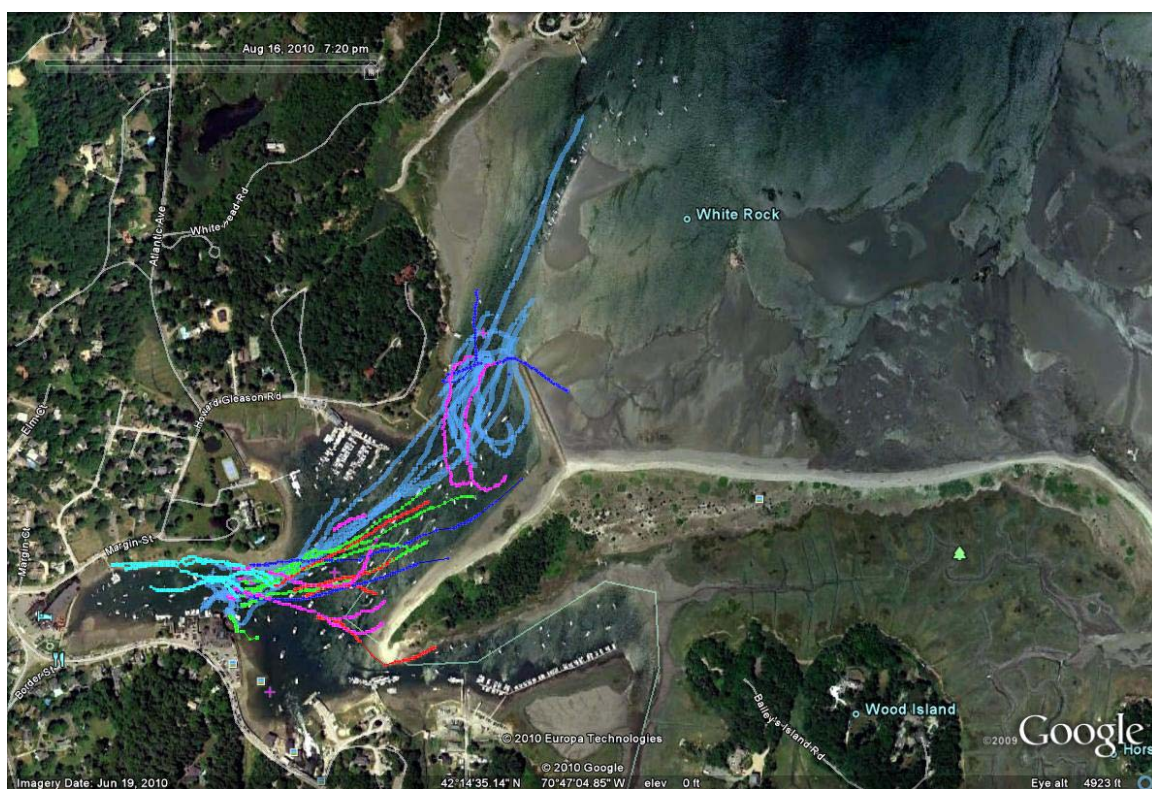


Figure 9. Tracks of surface GPS drifters collected in Cohasset Harbor in July-August, 2010

We used Garmin eTrex H GPS receivers (\$85) which can hold 10000 track points (in Active Log mode) and can last up to 17 hours on 2 AA batteries. We usually deployed 5 or 6 drifters two times per week at several designated locations within the harbor in order to quantify near surface water motions. Each drifter was monitored (and if necessary followed) by a student in a kayak or small boat for about one hour. GPS receivers were set to collect latitude and longitude fixes every 10 seconds. This procedure was repeated as many times as possible in order to cover different phases of the tide and wind conditions. Collected information will be used to calculate mean surface currents and eddy characteristics of the flow within the harbor. Figure 9 shows all the drifter tracks collected.

RESULTS

The conducted deployments allowed us to assess the performance of the SeaHorse current meter, evaluate different modes of deployment and recovery, the effects of bio-fouling. The results were presented at the 2010 Ocean Sciences Meeting (Sheremet, 2010) and during a number of seminars.

Analysis of the observational data in the Waquoit Bay and numerical modeling data revealed the causes of the irregularities of the tidal signal.

Detailed analysis of the observations is currently underway and will be combined with the numerical analysis of flows and seiches in Waquoit Bay during FY11. During the fall of 2010 the deployment in Waquoit Bay will be repeated and will be augmented by measurements of tidal elevations and launches of GPS drifters. We will use a modified mooring base in order to ensure fixed placement on the bottom.

IMPACT/APPLICATIONS

This instrument has a potentially a wide range of research, educational, aqua-cultural and navy applications. The efforts are underway in developing a deep see model with automatic relay of data at the end of deployment.

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